the Old World. Of course it is to be expected that Juniperus communis, which is indigenous in both Europe and Asia as well as North America, requires the same time to mature fruit in all regions. *Juniperus rigida* Sieb. & Zucc., of Japan, apparently also passes three seasons before arriving at maturity; but it seems hardly likely that all the species usually classed in this section, Oxycedrus, take so long before reaching full development. In the genus as a whole, probably a large proportion of the species ripen their fruits at the end of the second season; and there are others, besides Juniperus Virginiana, which mature their fruit in the same year in which they blossom.

It is almost impossible to determine these points with accuracy from ordinary herbarium specimens as they are generally collected, and, in making a study of the length of time required by the fruit of different species to arrive at maturity, herbarium material should be collected with special regard to this character; or, still better, the living plants should be carefully observed whenever possible.

For the accompanying plate and other assistance I am indebted to Mr. C. E. Faxon.

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Explanation of Plate XXXIII.—Fructification of *Juniperus communis* L. Fig. 1. Male branch with flowers. Fig. 2. Female branch, flowers and fruit. *a.* Flowers. *b.* Fruit, one year old. *c.* Fruit, two years old (May 25). Not mature until autumn. Fig. 3. Male flower, enlarged. Fig. 4. Scale of male flower, exterior view enlarged. Fig. 5. Scale of male flower, interior view, enlarged. Fig 6. Female flower, enlarged. Fig. 7. Fruit one year after flowering, transversely divided, enlarged. Fig. 8. Fruit two years after flowering, transverse section, enlarged. Fig. 9. Seed, two years from flowering, showing resin glands on the back, enlarged.

Development of the embryo-sac in Acer rubrum.

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WITH PLATE XXXIV.

A study of the development of the embryo-sac of *Acer rubrum* L. presents in itself nothing new or striking, but from the standpoint of comparative morphology it is not wholly without interest. This work represents only a part of a series of similar investigations to be made upon various angiosperms of both related and widely separated families.

Flowers of Acer rubrum in earlier stages of development may be obtained in winter and early spring, by removing the scales and fine silken hairs that enclose them in the bud. From buds taken in the latter part of March (the same condition may be found earlier), the ovules in the young female flower were in the stage of development represented in fig. 1.

In the apex of the nucellus will be found a cell much larger than the other cells, and with more densely stained contents. This is the mother-cell of the embryo-sac. At the time work was begun upon this subject I was unable to find flowers with younger ovules. The mother-cell, in all probability, arises from a single hypodermal cell, but as growth proceeds it soon becomes more deeply situated in the nucellus by the multiplication of the epidermal cells by tangential or periclinal divisions (fig. 2). A transverse section of the nucellus in this stage of development is shown in fig. 3, the larger central cell with large nucleus being the mother-cell of the embryo-sac. This cell which has now elongated considerably divides by a wall at right angles to its long axis (fig. 4). The upper cell divides again in a similar manner, so that there are three cells resulting from the mother-cell (fig. 5). The lower one of these three now enlarges gradually absorbing the two upper; its large nucleus soon divides, and the resulting nuclei move away from each other toward opposite ends of the cell (fig. 5). The further behavior of these nuclei is similar to that which obtains in all known embryo-sacs of angiosperms. The embryo-sac continually increases in size at the expense of the tissue of the nucellus immediately surrounding it.

The mature embryo-sac is broad at the micropylar end, but narrows gradually toward the antipodal end, which is occupied by the small antipodal cells (fig. 8). Here, as in almost all plants, one sees a considerable variation in the position of the endosperm nucleus. It may be close to the egg-apparatus (fig. 9), or more nearly midway between the ends, but always imbedded in the layer of protoplasm lining the interior of the sac, the central cavity of the sac being occupied by one or more large vacuoles. Here, however, the antipodal cells remain very small and their presence can be demonstrated only with considerable difficulty. They are soon absorbed after the embryo-sac is mature, the latter all the time increasing rapidly in size, especially if fertilization be effected.

One case was observed in which the three antipodal cells lay close together without cell-walls (fig. 10). In fig. 11, two naked cells may be seen with large vacuoles. These appeared to be undergoing disorganization.

The process of development in the embryo-sac of Acer rubrum is similar to that which takes place in few families of both monocotyledons and dicotyledons.[1]

It may be of interest to note that the pollen spores formed in the anthers of female flowers (fig. 12), though never becoming functional, develop normally. They are, as far as observation goes, almost precisely like those of the functional male flowers (fig. 13) with the two nuclei present which stain similarly to those of the functional spores. They are, however, smaller, one of the nuclei having a less definite membrane and the protoplasm consisting of a coarser reticulum, while the protoplasm of the functional pollen spores is of a more finely reticulated structure (fig. 13).

In female flowers, when the ovule has reached the stage shown in fig. 2, the four pollen spores have already been formed; the tetrads are, however, as yet enclosed by the wall of the mother-cell. Shortly after the flower opens these anthers shrivel and dry up.

The material for this study was fixed in a one per cent. aqueous solution of chromic acid, washed, stained *in toto* with alum cochineal, imbedded in paraffin, and sectioned on a Minot microtome, after which the sections were counterstained on the slide with a seventy per cent. alcoholic solution of Bismarck brown and mounted in Canada balsam.

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Explanation of Plate XXXIV.—Fig. 1, longitudinal section of young ovule; embryo-sac mother-cell with contents indicated. × 375. Fig. 2, same farther advanced; the outer integument on the right left off. × 375. Fig. 3, cross section of nucellus of a similar stage. × 375. Fig. 4, embryo-sac mother-cell divided by transverse wall. × 560. Fig. 5, embryo-sac mother-cell divided into three cells, the larger, lower one with large nucleus and two distinct nucleoli. × 560. Fig. 6, embryo-sac with two nuclei travelling toward opposite ends. × 560. Fig. 7, these nuclei have doubled and occupy the ends of the sac; a large vacuole occupying the cavity of the sac. × 375. Fig. 8, mature embryo-sac with surrounding cells of nucellus. × 279. Fig. 9, egg-apparatus; endosperm nucleus near it. × 375. Fig. 10, antipodal end, the cells lying free without definite walls. × 560. Fig. 11, two antipodal cells. × 560. Fig. 12, pollen spore of sterile stamen in female flower. × 375. Fig. 13, pollen spores of male flower. × 375.

[1] Strasburger: Angiospermen und Gymnospermen, Jena, 1879.